

**Subject:** Chains, Rings and Spectroscopy    **Code:** 2814

**Session:** Jan    **Year:** 2005

## **Mark Scheme**

<b>MAXIMUM MARK</b>	<b>90</b>
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## ADVICE TO EXAMINERS ON THE ANNOTATION OF SCRIPTS

1. Please ensure that you use the **final** version of the Mark Scheme.  
You are advised to destroy all draft versions.
2. Please mark all post-standardisation scripts in red ink. A tick (✓) should be used for each answer judged worthy of a mark. Ticks should be placed as close as possible to the point in the answer where the mark has been awarded. The number of ticks should be the same as the number of marks awarded. If two (or more) responses are required for one mark, use only one tick. Half marks should never be used.
3. The following annotations may be used in when marking. No comments should be written on scripts unless they relate directly to the mark scheme. Remember that scripts may be returned to centres.

<b>x</b>	=	incorrect response (errors may also be underlined)
<b>^</b>	=	omission of the correct response
<b>bod</b>	=	“benefit of the doubt” (where professional judgement has been used in deciding a response is worthy of a mark)
<b>ecf</b>	=	“error carried forward” (in consequential marking)
<b>con</b>	=	contradiction (in cases where candidates contradict themselves in the same response). No mark awarded, even if one response was correct. <sup>1</sup>
<b>sf</b>	=	error in the number of significant figures (only penalised once on the paper).
4. The marks awarded for each part question should be indicated in the margin provided on the right hand side of the page. The mark total for each question should be ringed at the end of the question, on the right hand side. These totals should be added up to give the final total on the front of the paper.
5. In cases where candidates are required to give a specific number of answers, (e.g. ‘give three reasons ...’), mark the first answer(s) given up to the total number required. Strike through the remainder. In specific cases where this rule cannot be applied, the exact procedure to be used is given in the mark scheme
6. Correct answers to calculations should gain full credit even if no working is shown, unless otherwise indicated on the mark scheme. (An instruction to ‘Show your working’ is to help candidates, who may then gain partial credit even if their final answer is not correct.)
7. Strike through all blank spaces and/or pages in order to give clear indication that the whole of the script has been considered.
8. An element of professional judgement is required in the marking of any written paper, and candidates may not use the exact words that appear in the mark scheme. If the science is correct and answers the question, then the mark(s) should normally be credited. If you are in doubt about the validity of any answer, contact your Team Leader/Principal Examiner for guidance.

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<sup>1</sup> Note that in organic chemistry a candidate may identify a compound by name and formula. If one of these is wrong then the mark is not awarded as this is a contradictory answer.

**Abbreviations,  
annotations and  
conventions used in the  
mark scheme**

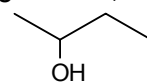
/ = alternative and acceptable answers for the same marking point  
; = separates marking points  
NOT = answers not worthy of credit  
( ) = words which are not essential to gain credit  
\_\_\_\_ (underlining) = key words which must be used  
ecf = allow error carried forward in consequential marking  
AW = alternative wording  
ora = or reverse argument

**Marking structures in  
organic chemistry**

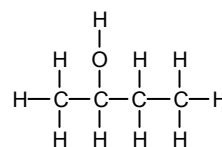
When a structure is asked for, there must be sufficient detail using conventional carbon skeleton and functional group formulae (e.g. CH<sub>3</sub>, C<sub>2</sub>H<sub>5</sub>, OH, COOH, COOCH<sub>3</sub>) to unambiguously define the arrangement of the atoms. (E.g. C<sub>3</sub>H<sub>7</sub> would not be sufficient).

If not specified by the question, this may be given as either:

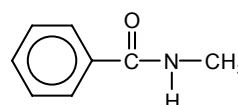
- a **structural formula** – e.g. CH<sub>3</sub>CH(OH)C<sub>2</sub>H<sub>5</sub>,



- a **skeletal formula** – e.g. ,



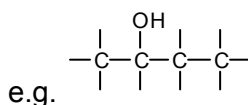
- a **displayed formula** – e.g.



or as a hybrid of these – e.g.

The following errors should be penalised – although each one only loses a maximum of one mark on the paper:

- clearly connecting a functional group by the wrong atom
- showing only 'sticks' instead of hydrogen atoms –



*Benzene rings may be represented as*



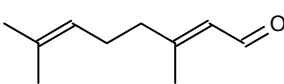
*as well as*



*in any*

*of the types of formula above.*

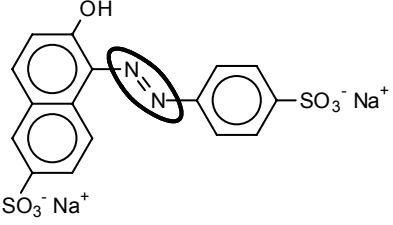
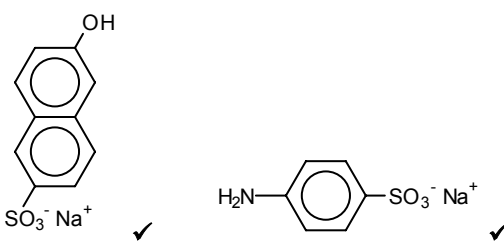
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Qu.	Expected answers:	Marks:																
1 (a) (i)	alkene / C=C double bond (primary) alcohol / hydroxy(l) ✓	[1]																
(b) (i)	molecules with the same structure / order of bonds ... but different arrangements in space / 3-D arrangement ✓	[1]																
(ii)	cis-trans / geometric ✓	[1]																
(iii)	the double bond does not rotate ✓	[1]																
(iv)	same groups at one end / need different groups at both ends of the C=C ✓ <b>AW</b>	[1]																
(c) (i)	 a correct skeletal aldehyde is shown on C <sub>1</sub> ✓ rest of the skeletal structure (C <sub>2</sub> -C <sub>10</sub> ) correct ✓	[2]																
(ii)	C <sub>9</sub> H <sub>15</sub> CH <sub>2</sub> OH + [O] → C <sub>9</sub> H <sub>15</sub> CHO ✓ + H <sub>2</sub> O ✓	<b>NOT</b> COH, allow C <sub>10</sub> H <sub>16</sub> O [2]																
(d) (i)	flavouring / fruity smell etc	<b>NOT</b> perfume or sweetener [1]																
(ii)	conc H <sub>2</sub> SO <sub>4</sub> ✓ reflux/ distil ✓	[2]																
(iii)	CH <sub>3</sub> COOH + C <sub>9</sub> H <sub>15</sub> CH <sub>2</sub> OH → CH <sub>3</sub> COOCH <sub>2</sub> C <sub>9</sub> H <sub>15</sub> + H <sub>2</sub> O ✓ ✓ ✓	allow C <sub>2</sub> H <sub>4</sub> O <sub>2</sub> and C <sub>12</sub> H <sub>20</sub> O <sub>2</sub> but <b>NOT</b> wrong structures allow ecf on the wrong acid [3]																
(e)	<table><tr><td>wavenumber range (cm<sup>-1</sup>)</td><td>3230-3550 (for OH)</td><td>1680-1750 (for C=O)</td><td>1000-1300 (for C-O)</td></tr><tr><td><b>geraniol</b></td><td>present ✓</td><td>(absent)</td><td>present ✓</td></tr><tr><td><b>aldehyde Y</b></td><td>(absent)</td><td>present ✓</td><td>(absent)</td></tr><tr><td><b>ester Z</b></td><td>(absent)</td><td>present ✓</td><td>present ✓</td></tr></table>	wavenumber range (cm <sup>-1</sup> )	3230-3550 (for OH)	1680-1750 (for C=O)	1000-1300 (for C-O)	<b>geraniol</b>	present ✓	(absent)	present ✓	<b>aldehyde Y</b>	(absent)	present ✓	(absent)	<b>ester Z</b>	(absent)	present ✓	present ✓	[5]
wavenumber range (cm <sup>-1</sup> )	3230-3550 (for OH)	1680-1750 (for C=O)	1000-1300 (for C-O)															
<b>geraniol</b>	present ✓	(absent)	present ✓															
<b>aldehyde Y</b>	(absent)	present ✓	(absent)															
<b>ester Z</b>	(absent)	present ✓	present ✓															
		<b>[Total: 20]</b>																

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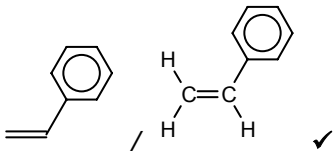
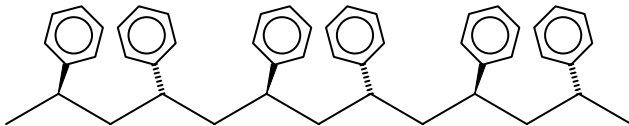
Qu.	Expected answers:	Marks:
2 (a)	any two of ... fibres / dyes / explosives / pharmaceuticals etc ✓✓	allow any specific examples as long as they do involve aromatic nitro or amine groups – eg <b>NOT</b> nylon, fertiliser etc [2]
(b)	temp 50-60° ✓ concentrated (acids) ✓	allow abbreviations for concentrated [2]
(c)	$C_6H_6 + HNO_3 \longrightarrow C_6H_5NO_2 + H_2O$ reactants ✓ products ✓	allow a balanced equation for multiple nitration at any positions [2]
(d) (i)	a pair of electrons ... ✓ ... (electrons) move / transferred / a (covalent) bond breaks/forms ✓	[2]
(ii)	it accepts a pair of electrons (from the benzene) ✓	<b>NOT</b> a 'lone' pair [1]
(iii)	$H^+$ (on the ring) is replaced by $NO_2^+$ ✓	allow 'substitutes' ignore $^+$ charges [1]
(iv)	it is not used up / reformed at the end <b>AW</b> ✓	[1]
(e)	$\pi$ -bonding electrons are <u>delocalised</u> ✓  <b>six</b> $\pi$ -electrons in benzene ✓ <b>four</b> $\pi$ -electrons in the intermediate ✓  $\pi$ -electrons are not over one carbon atom / over <b>five</b> carbon atoms / p-orbitals in the intermediate ✓  $\pi$ -electrons are over the <b>complete</b> ring / <b>all around</b> the ring <b>all six</b> carbon atoms/ p-orbitals overlapping ✓	this must be stated in words to compare benzene and the intermediate
	<b>Quality of written communication</b> for at least two sentences/statements with legible text and correct spelling, punctuation and grammar ✓	[6]
		<b>[Total: 17]</b>

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Qu.	Expected answers:	Marks:
3 (a)	<p><b>1<sup>st</sup> stage</b>  aromatic amine / named aromatic amine / structure ✓  sodium nitrite / nitrous acid ✓  HCl/H<sub>2</sub>SO<sub>4</sub> (but not conc) /H<sup>+</sup> ✓  at &lt;10°C ✓</p> <p>which forms a <u>diazonium</u> salt / ion ✓</p> <p><b>2<sup>nd</sup> stage</b>  the product from the first stage mixed with the phenol <b>AW</b> ✓  (in excess) hydroxide / alkali ✓</p>	<p>if more than four are given, mark any wrong reagents, conditions first</p> <p>allow correct formulae for the reagents</p> <p>[7]</p>
(b) (i)	 <p style="text-align: center;">✓</p>	<p>allow any benzene rings as well as N=N circled, as long as no other groups are</p> <p>[1]</p>
(ii)	<p>...16... carbon and .....10..... hydrogen atoms</p> <p style="text-align: center;">✓                      ✓</p>	<p>[2]</p>
(c)	<p>Na / NaOH / OH<sup>-</sup> etc ✓</p>	<p>[1]</p>
(d)	 <p style="text-align: center;">✓                      ✓</p>	<p>allow 1 mark if they are both correct, but in the wrong boxes</p> <p>only penalise a slip with SO<sub>3</sub><sup>-</sup> Na<sup>+</sup> once</p> <p>[2]</p>
		[Total: 13]



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Qu.	Expected answers:	Marks:
5 (a) (i)	addition (polymerisation) ✓	<b>NOT</b> additional [1]
(ii)		[1]
(iii)	<p><math>\pi</math>-bond breaks ✓</p> <p><b>many</b> molecules join / a <b>long</b> chain forms / equation to show this using 'n' ✓</p>	[2]
(b)	<p>alternating ✓</p>  <p>all four side groups placed above the chain with an alternating arrangement clearly shown by use of 3-D bonds ✓✓</p> <p>where 1 mark is for an incorrect diagram, but “(alternating) 3-D /spacial arrangement of side chains” stated in words</p>	[3]
(c)	<p>atactic has side chains irregular / random(ly arranged in space/3-D) ✓ <b>ora</b></p> <p>atactic has weaker intermolecular / Van der Waals' forces between the chains ✓ <b>ora</b></p> <p>chemically sensible suggestion why irregular side chains could give weaker forces – eg because chains can't get as close / less surface contact ✓ <b>AW ora</b></p>	<p><b>NOT</b> just “weaker bonds”</p> <p>[3]</p>
		<b>[Total: 10]</b>



**Qu. Expected answers:**
**Marks:**
**6 (a) (i)** Find the  $m/e$  of .... ✓

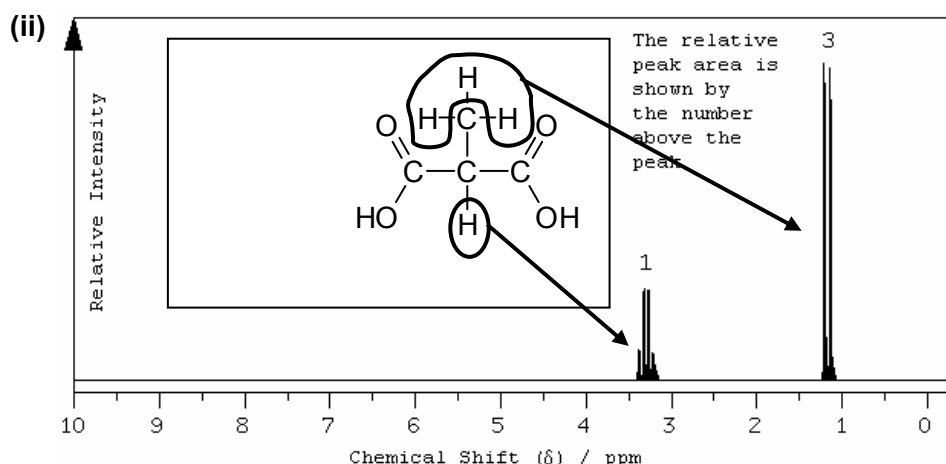
 ... the peak furthest to the right / with highest  $m/e$  or mass ✓

 allow attempts  
to cater for the  
 $^{13}\text{C}$  peak

**[2]**
 $\text{C}_2\text{H}_3\text{O}_2$  / empirical formula has  $M_r = 59$  ✓

 so  $M_r$  of molecular formula is  $^{118}/_{59} = 2$  / twice the empirical formula ✓

**[2]**
**(b) (i)** OH peak disappears (with  $\text{D}_2\text{O}$  / on the second spectrum)

**[1]**


peak at 3.3ppm identified as due to the CH ✓

 peak at 1.2ppm identified as due to the  $\text{CH}_3$  ✓

 assignment must  
be for this structure  
(not just  $\text{R-CH}_3$  etc)

protons (and not the carbon) on the groups are identified ✓

 can be by  $\text{H}_a$ ,  $\text{H}_b$   
etc

**relative peak areas / numbers above the peaks** show ...

 the number of (equivalent) protons in each group / three protons  
on one carbon and one on the other carbon ✓ **AW**
**quadruplet / 1:3:3:1 splitting** (of the peak at 3.3ppm) shows...

three protons on the neighbouring/adjacent carbon ✓

**doublet / 1:1 splitting** (of the peak at 1.2ppm) shows ...

one proton on the neighbouring /adjacent carbon ✓

**[6]**
**(iii)** no of peaks: one ✓

splitting: none ✓

all four protons equivalent / in the same environment ✓

 if the wrong structure  
is chosen allow ecf  
for:  
two peaks ✓,  
splitting ✓✓ (as last  
2 marks for part (ii) )

**[3]**
**[Total: 14]**